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13. ABSTRACT (Maximum 200 words)

The Aspen Workshop on Coherence and Chaos in Complex Dynamical Systems was attended by 25 scientists. There was much dialogue between scientists interested in rotating fluids, trapped electrons, turbulence, and chaos theory.

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SUMMARY OF THE 1991 ACP WORKSHOP

on

COHERENCE AND CHAOS IN COMPLEX DYNAMICAL SYSTEMS

The workshop was attended by 25 scientists, most of whom are specialists in various aspects of dynamical systems theory. A major success of the workshop was the opening of lines of communication between researchers from different areas. There was much dialogue between scientists interested in rotating fluids, trapped electrons, turbulence, and chaos theory. Thirteen lectures were given during the three weeks. A list of the lecturers, and a short summary of each of their talks is given below. The structure of the workshop was informal with one lecture per day with an afternoon tea. A keywords directory of the participants was compiled summarizing the participants backgrounds and interests: a copy is attached to this report, as is a list of the participants. Those attending the lectures usually included several participants from outside the workshop.

Organizers

J. D. Meiss
P. J. Morrison
J. Tennyson



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COHERENCE AND CHAOS IN COMPLEX DYNAMICAL SYSTEMS

TALKS WITH SUMMARIES

JUNE, 1991

- 5/29 "Subtle Symmetries in Quantum and Surface Wave Systems"
J. D. Crawford, Physics Dept., University of Pittsburgh
- A brief review of bifurcation theory and a discussion of the role of symmetry were given. These tools were used to understand wave phenomena in the Faraday experiment of Gollub et al and to clear up a misunderstanding of the role of symmetry in quantum well problems.
- 5/30 "Complexity Made Simple"
Seth Lloyd, Physics Dept., Caltech
- A survey of notions and advances in "Complexity Theory" such as algorithmic complexity, computational complexity, logical depth, mutual information and the amount of information processed by a system was given. These terms were brought to life by a series of examples ranging from modern art to the dripping faucet.
- 5/31 "The Gluing Bifurcation and Anomalous Period Doubling"
Bob Williams, Math Dept., University of Texas at Austin
- A review of the history of the Lorentz Attractor and period doubling bifurcation in the logistic map was given. Knottedness of the period doubling bifurcation sequence and the gluing bifurcation, which occurs in dynamical systems and maps with a discontinuity, were discussed.
- 6/3 "Nonlinearity in One-Dimensional Maps"
Peter Veerman, Math. Dept. SUNY
- A review of circle map phenomena such as periodic orbits, mode locking, Arnold tongues and the devil's staircase behavior of the rotation number were given. A summary of recent results for unimodal maps based on the bounded nonlinearity principle and Koebe's principle was given.
- 6/4 "Hidden Symmetries Using Lie Group Methods"
Barbara Shrauner, EE Dept. Washington University
- A discussion of how Lie symmetry techniques can be used to solve a variety of ordinary and partial differential equations for physical phenomena ranging from semi-conductors to plasma phenomena was given. A special kind of "hidden" symmetry was explained.

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- 6/5 "Turbulence and Coherent Structure in Shallow Rotating Flows"
Lee Panetta, Meteorology, Texas A&M

Fluid equations used to model oceans and atmospheres were presented along with notions such as the Beta effect and potential vorticity. Results of recent computations for the earth's jet stream revealed the formation of coherent structures out of turbulence.

- 6/6 "Hamiltonian Contour Dynamics"
George Bell, Jr., Boulder, Colorado

Contour dynamics is an approximation to vorticity advection models such as that describing quasigeostrophic motion in oceans and atmospheres. The Hamiltonian structure of this approximation was discussed and results of numerical simulation were presented and interpreted by making use of ideas from finite degree-of-freedom Hamiltonian chaos theory.

- 6/7 "Canonical Formalism for Wigner Functions"
Iwo Bialynicki-Birula, Phys. Dept., Univ. of Arizona

A general formalism for writing quantum mechanics in the Weyl-Wigner representation in terms of a generalization of Nambu dynamics was presented. The general Lie algebraic setting was shown how to be represented in terms of canonical Hamiltonian variables.

- 6/10 "Transient Chaos in Nonlocal Cellular Automata"
Wentian Li, Santa Fe Institute

Transient chaos and cellular automata were reviewed. A specific nonlocal cellular automata model was discussed in detail. An analogy to group meeting dynamics motivated the model and numerical observations of transient chaos behavior were given.

- 6/11 "Dynamics and Transport in Quasigeostrophic Flow"
Tom Solomon and Phil Morrison, Phys. Dept., Univ. of Texas

Theory and experiment of fluid flow in a rapidly rotating annulus were presented. It was observed that finite degree-of-freedom Hamiltonian dynamics explains features of the transport of a passive scalar in the experiment. A discussion of such chaotic advection was given.

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- 6/12 "The Anti-Integrable Limit for Area Preserving Maps"
Jim Meiss, Applied Math, Univer. of Colorado

Twist maps such as the standard map are generally studied as a function of a parameter k that measures the effect of "potential energy." Generally researchers have been interested in k near zero where the KAM theorem applies. The anti-integrable limit is the case where k approaches infinity. This limit provides a means for proving the existence of cantori.

- 6/13 "Resolution of Contradictions in Turbulent Diffusion Theory"
John Cary, Physics Dept., University of Colorado

A model known as quasilinear theory, developed in the 60's, for describing the turbulent relaxation of a weak beam in a plasma has recently come into dispute. Ideas from Hamiltonian chaos theory, such as island overlap, were shown to shed light on this dispute.

- 6/14 "Variable Stars as Dynamical Systems"
Robert Buchler, Physics Dept., Univ. of Florida

It was shown how a mixutre of numerical hydrodynamical and an analytical amplitude equation formalism sheds light on the nonlinear pulsations of stars. An explanation of the bump in classical Cepheids and of period doubling and chaos in the W. Virginia models were given.

Coherence and Chaos in Complex Dynamical Systems

Bell, George, Jr.	Hamiltonian dynamics, Geophysical fluid dynamics, contour dynamics.
Bialynicki-Birula, I.	Quantum electrodynamics, quantum optics, field theory, nonlinear PDE's.
Buchler, Robert	Astrophysics, Variable stars, Non-linear dynamics, chaos.
Cary, John	Dynamical systems, esp. plasmas, accelerators.
Colgate, Stirling	Astrophysics, supernova, hydrodynamics.
Crawford, J.D.	Plasma physics (collisionless plasma); nonlinear dynamics (bifurcation theory for symmetric systems.)
Drozda, Stan	Many-body problem, Quantum Chaos, Tunneling.
Eubank, Stephen	Time series analysis; nonlinear modeling and prediction.
Hanson, Jim	Magnetic Field Line Flow, Kinematic dynamos.
Kandrup, Henry	Galactic dynamics, Vlasov-Poisson, Vlasov-Einstein, quantum cosmology
Kaufman, Allan	Poisson Brackets for complex manifolds in dynamics.
Li, Wentian	Higher-dimensional dynamical systems (e.g. cellular automata), connection between dynamical systems and statistical physics.
Lloyd, Seth	Physics of Information, Foundations of quantum mechanics, measuring complexity.
Meiss, Jim	Dynamical systems, Hamiltonian Chaos.
Morrison, Phil	Hamiltonian systems (infinite and few degree-of-freedom), Plasma Physics, Hamiltonian transport in e.g. quasi geostrophic flows.
Oberman, C.	All aspects of nonlinear plasma dynamics (turbulence, chaos, coherent)
O'Neill, Tom	Nonneutral plasmas, transport, turbulence.
Panetta, Lee	Geophysical fluid dynamics, coherent structures in turbulence, non-standard analysis.
Shrauner, Barbara	Plasmas: processing, collisionless, transport in III-V semiconductors, Lie group methods for nonlinear systems.

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Shrauner, Ely	QFT, QCD pedagogy of nonlinearity.
Solomon, Tom	Transport & mixing; Hamiltonian dynamics; Geophysical fluid dynamics.
Taylor, Bryan	Plasma physics, relaxations, turbulence.
Uhlenbeck, Karen	Non-linear PDE and geometry, integrable systems.
Veerman, Peter	Twist maps, Unimodal maps, circle maps, scalings, renormalization, Thurston's Algorithm.
Williams, Bob	Strange attractors, knotted periodic orbits, symbolic dynamics.